1967

U.S. Forest Service Reseach Paper RM-31

Lumber Production From Selected Black Hills Ponderosa Pine

—Comparison of tree, log, and lumber volumes

—Percent of lumber by lumber grades

—Performance of log grades

—Feasibility of weight scaling

Lincoln A. Mueller
J. L. Kovner

ROCKY MOUNTAIN FOREST AND RANGE EXPERIMENT STATION
RAYMOND PRICE, DIRECTOR FORT COLLINS, COLORADO
FOREST SERVICE U. S. DEPARTMENT OF AGRICULTURE

The study reported here was conducted in 1962 as a team effort. It was planned and conducted by the Rocky Mountain Forest and Range Experiment Station and the Rocky Mountain Region of the U.S. Forest Service, with the cooperation, advice, assistance, and participation of the Black Hills Lumber Producers.

This study was designed primarily to check the adequacy of the tree volume tables that the Forest Service was using at the time by finding out how much and what quality of lumber can be obtained from the various combinations of sizes and grades of ponderosa pine logs that occur in the Black Hills. Obviously, not all the sizes and grades of logs needed for the study are equally available from the forests; some are common and abundant —others are scarce. Therefore, with regard to the average lumber recovery of the total sample, the data in this report do not necessarily represent lumber recovery that a lumber operator might expect from any given sale in the Black Hills. They do show, however, the amount and kind of lumber that can be cut from the particular diameter and grade of logs studied, and are comparable where such logs occur in sales. They must therefore be applied by the log diameters and grades as they occur in an actual sale to be meaningful.

The Ventling-Richtman Sawmill and the Custer Lumber Planing Mill provided the use of their plant facilities. The Buckingham Wood Products Company and the Homestake Mining Company provided men and equipment needed to select and handle the sample trees and logs. Mr. Bernard Potts of the Buckingham Company was especially helpful to the committee in assisting with selecting the sample trees and logs, and arranging for their procurement and delivery to the mill. Others who assisted include the Western Wood Products Association, the Forest Products Laboratory, and the Western Pine Log Grade Project.

U.S. Forest Service Research Paper RM-31 1967

LUMBER PRODUCTION FROM SELECTED BLACK HILLS PONDEROSA PINE

—Comparison of tree, log, and lumber volumes
—Percent of lumber by lumber grades
—Performance of log grades
—Feasibility of weight scaling

by

Lincoln A. Mueller, Principal Wood Technologist

and

J. L. Kovner, Principal Biometrician

Rocky Mountain Forest and Range Experiment Station[1]

[1] Central headquarters maintained in cooperation with Colorado State University at Fort Collins.

CONTENTS

	Page
Objectives	1
Methods	1
Selection of sample trees	2
Log weights	2
Mill yard scaling, grading,diagraming	4
Sawmill procedure	4
Sawing accuracy	4
Lumber seasoning	4
Rough dry grading	5
Finished dry grading	5
Defects	6
Results	6
Comparison of tree volumes, log volumes, finished lumber tally	6
Lumber grade recovery	8
Volume and grade changes resulting from seasoning and surfacing	8
Sawing accuracy	13
Lumber volume and overrun	13
Performance of log grades	13
Performance of revised scaling method	16
Weight scaling	17
Summary and conclusions	18
Appendix	19

LUMBER PRODUCTION FROM SELECTED BLACK HILLS PONDEROSA PINE

—Comparison of tree, log, and lumber volumes
—Percent of lumber by lumber grades
—Performance of log grades
—Feasibility of weight scaling

by
Lincoln A. Mueller and J. L. Kovner

The commercial forest land of the Black Hills extends over an area of approximately 1.3 million acres. The sawtimber volume, including all trees 11 inches in diameter breast high (d.b.h.) and up and based on International ¼-inch rule, totals 3.4 billion bd. ft. Poletimber stands in the 5 to 11-inch d.b.h. class account for a volume of 271 M cu. ft.[2]

From the time of the first settlement in the Black Hills in 1876 to the present, lumbering has been the major wood-using industry. Except for periods of war and depression, the industry has demonstrated rather steady growth, and has played an increasingly important role in the economy of the area.

As in other lumber-producing areas, increasing competition from other construction materials for the markets formerly served by the common grades of lumber have cut deeply into the returns from lumber production. This trend has had a great impact on producers in the Black Hills because so much of the lumber from Black Hills timber is in the common grades. The situation requires a general tightening up in all expenditures and practices. What were formerly tolerable errors in the estimate of the volume and quality of the timber, or in the logging or milling costs and lumber yields, can no longer be accepted if the industry is to survive and prosper.

Objectives

Better data were needed as a basis for Forest Service timber appraisals. This study was designed to provide such data, plus related information that would apply to the general problem.

[2] *Caporaso, A. P. Forest area and timber volume in western South Dakota. U. S. Forest Serv. Res. Note INT-20, 4 pp., illus. 1964.*

The major objectives, generally agreed upon by the industry and the Forest Service, were:

1. To obtain data identifying logs and lumber from trees in various Black Hills timber stands as a basis for (a) developing gross and net tree volume tables, and (b) developing tree-measurement performance tables.
2. To develop performance tables for lumber recovery in standard lumber grades from Black Hills ponderosa pine at a sawmill equipped with a circular headrig and a sash cant resaw (lumber grade recovery, volume recovery, and value recovery, all on dry, surfaced basis).
3. To evaluate the Improved Ponderosa Pine Log Grades[3] (see appendix, p.19).
4. To evaluate the feasibility of scaling Black Hills ponderosa pine saw logs by weight.

Secondary objectives were:

1. To determine the possibility of developing improved criteria for identifying the presence and extent of scalable defects.
2. To compare the scaling method in use with a revised method.
3. To estimate the volume and grade of losses resulting from seasoning and surfacing.
4. To determine the accuracy of sawing.

Methods

The logs were processed at the Ventling-Richtman Sawmill and Custer Lumber Planing Mill in Custer, South Dakota (fig. 1). The sawmill used circular headrig-sash cant gang resaw equipment as specified in the study plan. The milling firm also had dry kiln facilities.

[3] *Gaines, Edward M. Improved system for grading ponderosa pine and sugar pine saw logs in trees. U. S. Forest Serv., Pacific Southwest Forest and Range Exp. Sta. Tech. Pap. 75, 21 pp., illus. 1962.*

In addition, the study mill was centrally located with regard to the timber sites to be sampled.

Selection of Sample Trees

Five hundred sample trees were selected for the study. The selection was made, as far as possible, from trees that had been marked for cutting on or near going timber sales. Exceptions were made where necessary to obtain an adequate sample of the diameters and grades called for in the study plan. The sampling was spread over 5 of the 10 Ranger Districts to include trees from a broad area of the Black Hills National Forest (fig. 2). The sample trees were selected by a three-man crew made up of qualified representatives of the lumber operators, National Forest Resource Management, and Forestry Research.

Trees used in the study were randomly selected by the three-man team within the general criteria shown below to provide a reasonably weighted sample of each of the various log diameters and grades in the Black Hills:

	Trees required— From each sample area (Number)	Trees required— Total (Number)	Portion of butt logs distributed in grades 1,2,3
Tree size class: (Inches d.b.h.)			
10-12	15	75	—
13-15	30	150	—
16-18	20	100	1/3
19-21	10	50	1/2
22-24	10	50	1/2
25+	15	75	1/2
Total	100	500	

The crew maintained a continuous tally on a tree-diameter and grade tally sheet. This record provided a ready reference for determining the number and kinds of trees still required for the sample. Once a tree was selected, the sampling crew marked it and made the measurements necessary to determine its volume. The crew also graded the logs in the standing tree by both the Pacific Northwest[4] and Improved Ponderosa Pine Log Grades for comparison purposes. The tree-measurement data and log-grade information were recorded on a tree-measurement form.

When a sample tree was felled, an orientation line was painted along the length of the bole to designate the boundary between log faces one and two in subsequent log diagraming. This made it possible to orient the logs produced from any given tree from the log diagrams. Various tree and log measurements required by the study plan were also taken.

As the trees were bucked into logs, tree and log numbers were painted on the log ends so that the position of each log in the tree could be identified. The woods scaling and log grading were also accomplished at this time. A record was kept of any sections of the trees broken during felling and which became too short to be merchantable. All data collected on the felled trees were recorded on a tree-measurement form.

Log Weights

As the logs were hauled to the study mill in Custer, each truckload was weighed to develop data for determining the feasibility of weight scaling. At the mill, each log on the load was recorded by tree and log number to relate the log scale to weight. All weights and log identity were recorded on a load-weight log-number tally sheet.

[4] *Ponderosa pine log grade descriptions as reworded on November 1, 1938--Pacific Northwest Forest and Range Experiment Station, Portland, Oregon. Hilgardia 21: 103. 1951.*

Figure 1.--The Ventling-Richtman Sawmill and Custer Lumber Planing Mill, Custer, South Dakota.

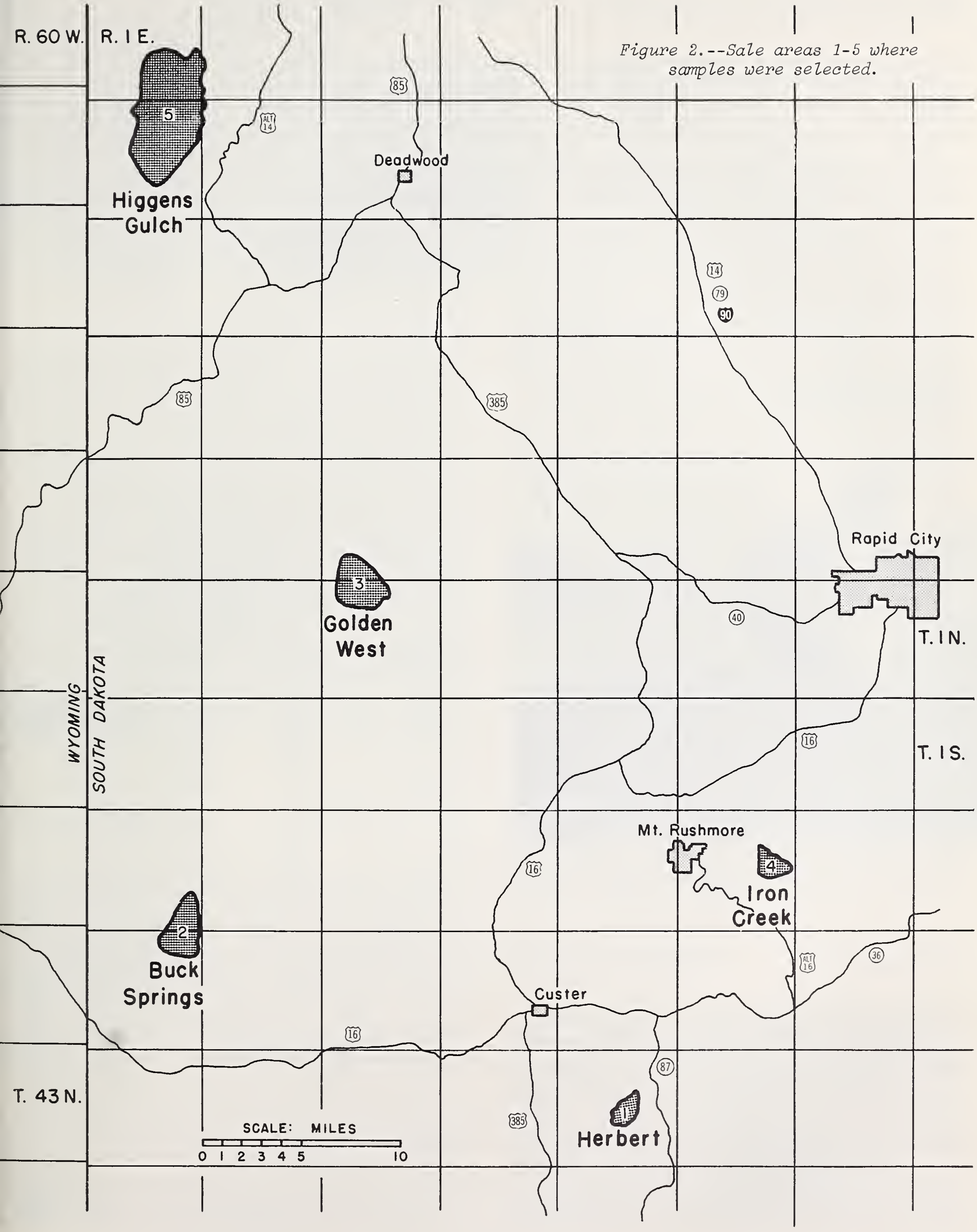

Figure 2.--Sale areas 1-5 where samples were selected.

Mill Yard Scaling, Grading, Diagraming

In the mill yard, all study logs were diagramed and graded again by the two log grading systems (fig. 3). Diagraming was supervised by personnel of the Ponderosa Pine National Log Grade Project; logs were graded by the Forest Service check grader attached to the Washington Office. Log diagrams were recorded on a standard log diagram form. Logs were also rescaled at this point by the Forest Service check scaler, and also, independently, by the Western Wood Products Association's check scaler. The Forest Service scaler used both the current method used on timber sales in the Black Hills,[5] and the revised method[6] used in western regions since 1963. All Forest Service scaling volumes were identified by tree and log number, and were recorded in standard log-scale record books.

Figure 3.--Scaling and grading study logs enroute to mill.

Sawmill Procedure

During a half-day trial run, the mill crew was trained, the planned marking and recording system was tried, and the mill was checked out by a sawmill specialist. It was found to be in good order. Instructions issued to the mill superintendent provided for cutting all 4/4 lumber for highest possible grade recovery in conformance with Western Wood Products Association standards.

As each study log entered the mill, it was marked with a mill log number, which was cross-referenced to the field tree and log numbers, so that a consecutive numbering system could be used at the mill. As an added precaution against loss of identity of the lumber, the mill log numbers were put on in five distinctive colors. This practice was also followed at the head saw to identify cants for resawing, and on lumber edged on the head saw and sent directly to the trimmer. In addition, the mill log number was stamped near both ends of all boards sawed in the gang or circular saw. All boards were thus identified, and could be related back to the log and tree from which they were produced.

The rough-green lumber was sorted by width by means of an edge sorter as it emerged from the mill. A complete tally by mill log number and board size was made at this point and recorded on a tally sheet. The green lumber was not graded except for separation of selects and shop for seasoning purposes, and identification of grade 5 common. Green grade 5 boards were omitted from the remainder of the study since this grade could not be profitably marketed at the time, and the industry representatives felt it should not be considered as part of the lumber recovery. Later in the study, grade 5 boards that resulted from seasoning and surfacing degrade were included.

Sawing Accuracy

To develop information on the quality of sawing, thickness and width were measured on a sample of 100 boards in each width class. Thicknesses were gaged to the nearest 1/32 inch, and widths were measured to the nearest 1/8 inch. The thickness was measured on alternate edges at the midpoint and 2 feet from each end. Width was measured at the same locations. This information was recorded on the lumber-measurement form.

Lumber Seasoning

All lumber produced in the study (except 5 common, rough green) was kiln dried. The

[5] *U. S. Forest Service. National Forest log scaling handbook. 119 pp. Washington, D. C.: U. S. GPO. 1941.*

[6] *U. S. Forest Service. National Forest log scaling handbook. 193 pp. Washington, D. C.: U. S. GPO. 1964.*

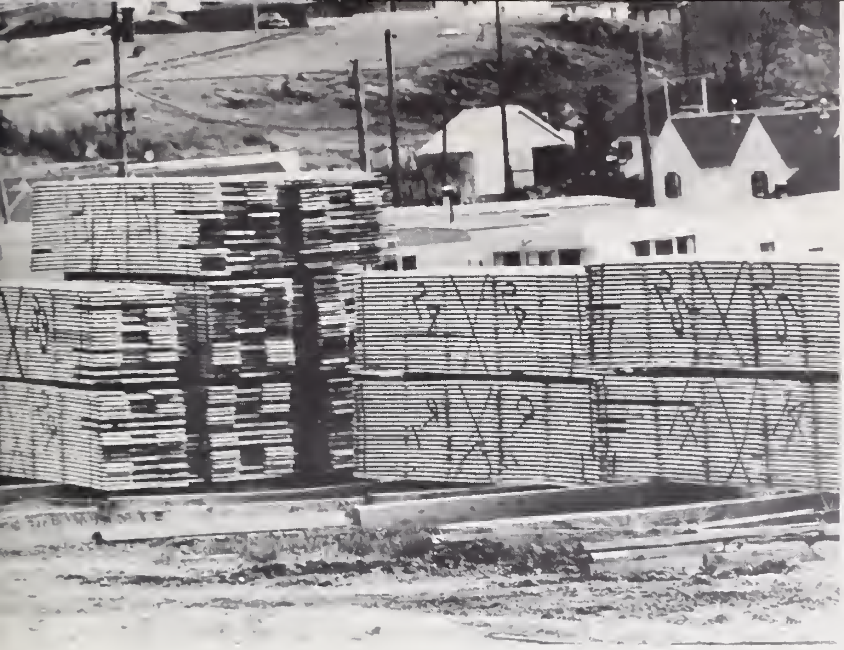

Figure 4.--Study lumber piled for kiln drying. Each package was numbered to facilitate record keeping.

lumber was box piled in packages at the edge sorter, and later transferred to the storage yard to await kiln drying (fig. 4). Select and shop grades were placed in separate packages so they could be dried under a different schedule than the common grades. A record of the piles by number was maintained on a lumber-pile tally sheet.

The cooperating company used two double-track, cross-circulation internal fan kilns with 120,000 bd. ft. capacity. The kilns were inspected by a kiln specialist and found to be satisfactory. The same schedules used by the firm for drying their regular production were also used for the study lumber:

	Dry bulb	Wet bulb	Duration
	—(°F.)—		(Hrs.)
Selects or upper grades[1]	140	120	16-24
	150	128	16
	160	130	30
	170	130	[2] 22-34
Common grades	140	120	16
	160	135	24
	160	130	24
	170	130	[3] 20-32

[1] Also used in mixed charges of selects and commons.
[2] Or until at desired moisture content.
[3] Or until at 12-14 percent.

Study boards were dried to approximately 8 percent for select and shop grades, and to within 12 to 14 percent for common grades.

Numerous moisture determinations were made of the lumber after it was removed from the kiln. Inspections for evidence of excessive checking and uniformity of moisture content revealed that quality of the seasoning was high and well within the standards set by the Western Wood Products Association.

Rough Dry Grading

All seasoned lumber was graded by a certified Western Wood Products Association Grader. Rough-dry lumber was graded as it was run through the open planer enroute to the trimmer to provide imformation on volume and grade losses from seasoning. The grader designated the boards and the amount to be trimmed, and graded on the basis of trimmed length. To facilitate transfer of board numbers from the face to the end, required to maintain identity after surfacing, a thin wafer was trimmed from the base end of each board during the rough-dry sort. As the boards emerged from the trimmer, they were stacked, by grade and length, in piles along the length of the dry chain. A tally man and a lumber marker were assigned to each stack or to several stacks, depending on the volume involved. The marker would call out the board size and number to the tally man, and at the same time transfer the board number to the trimmed end section with a felt-tipped marker. The tally was recorded on a dry-lumber tally sheet. This material was returned to the storage yard and grouped by grade to await planing.

Finished Dry Grading

The surfaced lumber was given a final finished grade. Except where the numbered ends were involved, any additional trimming necessary after surfacing was handled in the same manner as described under the rough-dry grades. Boards requiring trim on the numbered end were pulled, and the number was transferred to the edge before final trimming.

The finished graded and trimmed lumber was again sorted by grade and board size, and stacked along the length of the chain. Final

tally was made at this point and recorded on the lumber-tally form.

Defects

Another phase of the study concerned the improved scaling and detection of scalable defects. Volume differences resulting from failure to make proper adjustments for defects can offset the value of the most carefully prepared volume tables and log grades. The problem is complicated by the presence of hidden defects not visible to cruisers or scalers.

Past studies have shown that scalable defects in logs generally tend to increase the overrun. This is due to overestimating the extent of the defect, or to recovering part of the deducted volume as low-grade lumber. Hidden defects tend to reduce overrun.

The differences between estimated log-scale volumes and actual lumber-recovery volumes have been of much concern to both industry and the Forest Service. This concern led to the revised scaling procedure tried in this study. (See Mill Yard Scaling, Grading, Diagraming, p. 4.) To facilitate the tests, the scaler was required to identify each scale deduction with the type of defect.

In the portion of the defect study concerned with developing procedures or techniques to better identify the presence of hidden defects, the boards from all logs that were canted in the head saw and routed through the sash cant gang saw were photographed. This accounted for all but a few of the logs that were too defective to convert to cants on the head saw. The photographs were later compared with the log diagrams and scaling records for possible correlation with external characteristics. This phase of the study is continuing and will be reported separately.

Results

Comparison of Tree Volumes, Log Volumes, and Finished Lumber Tally

A major objective of the study was to determine the adequacy of the net tree volume tables used by the Forest Service in the Black Hills. This was accomplished by measuring the tree, standing and felled, and determining its volume from the net volume table. This volume was compared with the volume determined by log scale and the finished lumber tally (table 1). The volumes of standing trees were based on measured d.b.h. and estimated tree height. For the felled trees, actual height (length of the trunk to a minimum top diameter of 8 inches) was measured. The most important comparisons are those made within each tree size class. Totals for all trees in the study are indicative also. Overrun percentages for all trees were not computed, however, because of the restricted nature of the sampling.

The net tree volumes predicted by the volume tables agree sufficiently with the Forest Service[7] net log scale to warrant use of the volume tables for timber sale appraisal work. This conclusion is based on the fact that, with one exception, the volume differences for all trees up to and including the 23-inch diameter class are within 10 percent. Also, in 9 of these 14 diameter classes, the differences are less than 5 percent. The more erratic behavior in the diameter classes above 23 inches indicates that volume tables should be strengthened although these trees compose a very small proportion of the total volume. Overall results do not reveal any regular bias, as can be observed by the agreement in the grand totals and alternation of plus and minus differences.

Table 1 does not support the likely assumption that measuring bole length would make volumes estimated from measurements of felled trees more accurate than those from measurements of standing trees.

The relatively large differences between gross tree volumes (standing and felled) and gross Forest Service and Western Wood Products Association log-scale volumes is due (1) to the cull logs that were left in the woods, and (2) to a lesser extent to losses incurred in felling and bucking when some tree segments were broken and became too short to be used at the mill. These unmerchantable materials were left in the woods and not used further in the study. The gross scale of the 259 logs that were culled in the woods and not brought into the mill yard is shown in table 1 under column entitled Cull Logs.

The overrun columns in table 1 show the relationships between net tree volumes, estimated from the volume table and by log scaling, and actual recovery of merchantable dry finished lumber. This comparison differs from the usual method of showing overrun in which the log-scale volumes, grouped by log-scaling diameters, are compared to the lumber recovery (see table 8, p.15). Both methods of comparison, however, illustrate the usual

[7] *The Forest Service log scale was used as standard in the study.*

Table 1.--Comparison of net tree volumes,[1] based on standing and felled trees and on log scale,[2] with actual recovery of merchantable dry-finished lumber

Tree d.i.b. (Inches)	Sample trees	Tree volumes				Log scale volumes						Cull logs	Lumber volume	Overrun or underrun[5]			Difference[6]
		Standing		Felled		FS log scale		WWPA log scale		Woods scale[4]			Lumber tally, dry-finished	Standing trees	Felled trees	FS log scale	
		Gross	Net	Gross	Net	Gross[3]	Net	Gross[3]	Net	Gross	Net						
	No.	Board feet												Percent			
10-10.9	10	400	350	530	440	390	360	400	360	470	400	50	460.4	31.5	4.6	27.9	-2.8
11-11.9	24	1,500	1,260	1,570	1,330	1,380	1,240	1,410	1,260	1,510	1,350	70	1,512.1	20.0	13.7	21.9	-1.6
12-12.9	37	3,060	2,530	3,470	2,850	3,060	2,880	3,190	2,890	3,320	3,060	60	3,510.3	38.7	23.2	21.9	+12.1
13-13.9	52	6,310	5,230	6,450	5,330	5,550	5,210	5,570	5,020	6,070	5,350	310	5,823.6	11.3	9.3	11.8	-.4
14-14.9	48	7,680	5,930	8,070	6,260	7,160	6,520	7,290	6,520	7,900	6,720	490	7,391.4	24.6	18.1	13.4	+9.0
15-15.9	50	9,420	7,460	9,990	7,900	8,100	7,610	8,250	7,410	9,130	7,560	590	8,192.4	9.8	3.7	7.6	+2.0
16-16.9	34	8,180	6,390	8,620	6,720	7,450	6,760	7,730	6,520	8,190	6,760	440	7,797.6	22.0	16.0	15.3	+5.5
17-17.9	37	11,190	8,640	11,430	8,820	9,460	8,590	9,680	8,510	1,084	8,750	860	9,470.8	9.6	7.4	10.2	-.6
18-18.9	29	9,480	7,220	9,890	7,540	7,970	7,200	7,860	6,850	9,100	7,540	870	8,276.5	14.6	9.8	15.0	-.3
19-19.9	24	9,600	7,320	9,610	7,320	8,120	7,070	8,090	6,820	9,390	6,930	1,140	7,498.6	2.4	2.4	6.1	-3.5
20-20.9	20	9,620	7,350	9,840	7,550	8,200	7,480	8,300	7,350	9,640	7,690	1,040	7,940.0	8.0	5.2	6.1	+1.7
21-21.9	11	5,430	4,170	5,670	4,320	4,940	4,420	5,020	4,250	6,030	4,360	780	4,524.6	8.5	4.7	2.3	+5.7
22-22.9	16	8,790	6,650	9,420	7,120	7,710	6,960	7,880	6,560	9,250	6,940	1,180	7,052.6	6.0	-1.0	1.3	+4.5
23-23.9	14	10,030	7,580	10,100	7,640	8,140	7,030	8,370	6,740	10,060	7,400	1,370	7,003.1	-7.6	-8.3	-.4	-7.8
24-24.9	18	12,440	9,330	12,990	9,760	9,940	7,930	10,190	6,830	12,540	7,930	2,180	7,534.6	-19.2	-22.8	-5.0	-17.6
25-25.9	18	14,630	10,980	14,830	11,170	11,670	9,400	11,680	8,610	13,990	10,090	1,620	9,321.4	-15.1	-16.6	-.8	-16.8
26-26.9	14	12,030	9,020	13,020	9,770	12,530	11,120	12,620	10,280	13,650	11,280	220	10,841.7	20.2	11.0	-2.5	+18.9
27-27.9	16	15,160	11,370	16,240	12,190	12,690	11,150	13,110	10,720	15,610	11,100	2,240	10,725.1	-5.7	-12.0	-3.8	-2.0
28-28.9	9	9,590	7,200	9,460	7,110	7,880	6,530	7,990	6,420	10,130	7,040	1,950	6,040.9	-16.1	-15.0	-7.5	-10.3
29-29.9	7	8,070	6,070	8,490	6,360	6,910	5,870	6,940	5,640	8,940	6,150	1,580	5,265.9	-13.2	-17.2	-10.3	-3.4
30-30.9	1	1,240	930	1,240	930	1,200	1,110	1,200	1,140	1,290	1,210	40	1,113.8	19.8	19.8	.3	+16.2
31-31.9	4	5,280	3,950	5,760	4,280	4,670	4,200	4,600	3,920	5,030	4,530	260	3,925.6	-.6	-8.3	-6.5	+6.0
32-32.9	2	3,310	2,460	3,480	2,570	3,160	2,680	3,240	2,560	3,300	2,990	60	2,288.5	-7.0	-11.0	-14.6	+8.2
33-33.9	1	1,670	1,120	1,490	1,120	1,510	1,410	1,470	1,380	1,540	1,530	0	1,268.7	13.3	13.3	10.0	+20.6
34-34.9	2	2,800	2,110	3,000	2,250	3,000	2,380	3,140	1,960	3,110	2,520	0	1,664.1	-21.1	-26.0	-30.1	+11.3
Total	498	186,910	142,620	194,660	148,650	162,790	143,110	165,220	136,520	190,030	147,180	19,220	146,444.3				

[1] Based on net tree volume tables in use at time of study.
[2] All log scales shown are based on Scribner Decimal "C" scale.
[3] FS and WWPA gross log scales do not include volume of logs that were scaled as cull in the woods and not brought in to the mill. The gross scale of these 259 logs is shown in "Cull Logs" column, and is included in gross woods scale.
[4] Includes scale of two merchantable trees totaling 200 bd. ft. gross and 120 bd. ft. net that were not brought in to the mill.
[5] Refers to difference in lumber volume between actual lumber tally and volumes predicted by net tree volumes shown and net FS log scale.
[6] Between FS net log scale and net standing volume.

Scribner Decimal C log-scale pattern of substantial overrun from the smaller logs and underrun from larger logs.

Lumber Grade Recovery

A second major objective of the study was to determine the yields of lumber in the various lumber grades recovered from the study logs. This information is of importance to both the buyer and seller of sawtimber, because it provides the best measure of the quality of the timber. It is also of prime importance to the forest manager, since it offers him a concrete means of determining how the various silvicultural practices influence quality. The data are likewise of value to wood-using industries, whose production is frequently limited by the quality of the raw material.

Lumber grade recovery data can be used to compare alternative log-grading systems, and determine which system best accounts for the effects of log size and log soundness on actual lumber yields.

Lumber grade recovery data for this study are summarized in tables 2 through 5. The data are listed separately for each combination of log grade and diameter class. Data also are shown separately for sound logs and those with scalable defects. Log length was not considered in this part of the analysis, since there were too few logs in lengths other than 16 feet when separated by log grades and diameters. There is no table for log grade 4 because there were only two logs in this grade.

The percentage of lumber volumes recovered in the different grades varied directly with the log grades. Grade 1 logs yielded the highest proportion of lumber in the upper lumber grades, and grade 5 logs yielded mostly low common lumber grades.

The relation of diameter to grade recovery within each log grade was also quite evident, especially in the distribution of the common grades. In general, for all grades of logs in the diameters well represented, the small logs (16 inches and smaller) tended to yield more of the upper common grades of lumber, (1, 2, and 3 common), and the larger diameter logs yielded a higher proportion of selects and lower common grades (4 and 5). A similar relationship between log size and lumber grades was found in an earlier study of Black Hills ponderosa pine, [8] based on lumber recovery from 1,840 logs selected randomly from the log decks of four different mills. In this earlier study, 94 percent of the logs were in the 7 to 16-inch diameter class; in the present study, this size class made up 77 percent of the total number of logs.

On the basis of the Forest Service log scale, 872 (approximately 60 percent) of the logs run through the mill were scaled as sound or full scale, and 594 (approximately 40 percent) were scaled as defective or having scalable defects. These proportions do not include the 259 logs that were scaled as cull in the woods and not brought into the mill. Inclusion of these cull logs in the total on the strength that they were part of the study would increase the total "defective" logs to 853, or about 50 percent. In addition, some decay was observed during the sawing operation in 252 of the logs that were scaled as sound, or in which no scalable defects were detected by the scaler. Addition of these logs would place the total number of defective logs at 1,105 or approximately 64 percent of the total.

In the earlier study,[8] 42 percent of the logs run through the mill were scaled as defective; data on the number of logs culled in the woods or the number of sound or full-scale logs that contained hidden defects detected by the scaler are not available.

Full-scale logs generally produced higher yields of upper common grades of lumber, and the logs with scalable defect produced higher yields of No. 1 shop and better grades (tables 2-5). This seems to be due to the relationship between log diameter and soundness class. Generally, the small-diameter logs that yield much of the better common grades of lumber are sound, while more of the larger logs, which produce most of the upper grades of lumber, have some scalable defect.

Volume and Grade Changes Resulting From Seasoning and Surfacing

Total volumes of lumber produced in the green, rough-dry, and finished-dry condition were determined. In the latter two categories, the volume by grade was ascertained also. It was possible, therefore, to determine the total volume lost between green and rough-or finished-dry, and also the grade and volume changes between the rough-dry and finished-dry stages of processing.

The total volume of green lumber tallied, not including 5,500 bd. ft. of unmerchantable grade 5 that was discarded in the rough-green,

[8] Landt, E. F., and Woodfin, R. O., Jr. Amounts and grades of lumber from Black Hills ponderosa pine logs. U.S. Forest Serv., Rocky Mountain Forest and Range Exp. Sta., Sta. Pap. 42, 24 pp., illus. 1959.

Table 2.--Recovery of lumber by grade from Black Hills ponderosa pine (dry-finished basis)

IMPROVED LOG GRADE 1

Log diameter (Inches)	Logs	Select			Moulding	Factory select	No. 1 shop	Common			
		B	C	D				1 & 2	3	4	[1] 5
	No.	Percent									
					ALL LOGS						
12	2	0	7.9	37.8	0	0	0	41.4	4.3	8.6	0
13	3	6.4	4.3	32.5	0	4.2	2.8	21.2	15.5	10.6	2.5
14	4	0	10.6	30.7	0	0	1.6	14.9	35.4	6.8	0
15	5	.7	12.9	33.4	1.8	0	0	9.2	11.1	30.5	.4
16	2	1.4	21.9	22.9	0	0	2.4	3.8	18.3	27.9	1.4
17	4	2.0	26.7	28.3	0	0	1.5	23.6	10.1	7.8	0
18	4	.9	18.1	22.3	0	.4	1.3	17.1	20.9	19.0	0
19	3	2.3	23.9	26.1	1.0	2.1	1.7	17.2	9.9	12.8	3.0
20	2	9.6	20.0	16.5	0	1.5	0	7.3	13.0	26.4	5.7
21	1	9.6	25.4	11.9	0	0	8.4	0	0	39.5	5.2
22	3	6.9	21.1	23.6	4.3	3.7	3.2	1.9	19.0	15.1	1.2
23	2	2.5	28.4	30.6	0	.5	1.8	1.4	15.5	19.3	0
24	3	.4	17.5	36.3	0	.7	1.5	5.2	4.1	33.4	.9
25	1	4.7	25.3	19.6	0	4.0	0	2.4	13.3	28.5	2.2
26	2	1.1	8.0	27.7	.4	0	.9	1.7	29.7	30.3	.2
Total	41										
					ALL FULL-SCALE LOGS[2]						
13	1	15.5	0	36.2	0	10.3	0	20.7	13.8	0	3.5
14	0	0	0	0	0	0	0	0	0	0	0
15	1	0	37.5	37.5	0	0	0	0	0	0	25.0
16	1	2.4	25.5	18.1	0	0	0	2.4	27.3	24.3	0
17	1	0	9.5	30.0	0	0	0	43.7	7.3	9.5	0
18	1	0	34.9	23.4	0	0	0	16.4	11.0	14.3	0
19	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0
21	1	9.6	25.4	11.9	0	0	8.4	0	0	39.5	5.2
22	1	15.3	20.4	17.4	0	4.2	8.3	0	15.6	18.8	0
23	0	0	0	0	0	0	0	0	0	0	0
24	1	0	7.6	53.8	0	0	0	11.9	8.4	17.3	1.0
Total	8										
					ALL PARTIAL-SCALE LOGS[3]						
12	2	0	7.9	37.8	0	0	0	41.4	4.3	8.6	0
13	2	0	7.2	29.9	0	0	4.8	21.6	16.7	18.0	1.8
14	4	0	10.6	30.7	0	0	1.6	14.9	35.4	6.8	0
15	4	.7	12.4	33.3	1.8	0	0	9.4	11.3	31.1	0
16	1	0	17.0	29.6	0	0	5.6	5.6	5.9	32.9	3.4
17	3	2.7	33.1	27.7	0	0	2.0	16.1	11.2	7.2	0
18	3	1.2	12.5	21.9	0	.5	1.7	17.3	24.3	20.6	0
19	3	2.3	23.9	26.1	1.0	2.1	1.7	17.2	9.9	12.8	3.0
20	2	9.6	20.0	16.5	0	1.5	0	7.3	13.0	26.4	5.7
22	2	1.7	21.6	27.4	7.0	3.4	0	3.1	21.0	12.9	1.9
23	2	2.5	28.4	30.6	0	.5	1.8	1.4	15.5	19.3	0
24	2	.8	25.0	22.8	0	1.3	2.7	0	.8	45.8	.8
25	1	4.7	25.3	19.6	0	4.0	0	2.4	13.3	28.5	2.2
26	2	1.1	8.0	27.7	.4	0	.9	1.7	29.7	30.3	.2
Total	33										

[1] Volume derived from downgrade of higher grades.
[2] Logs free of any scalable defects.
[3] Logs with scalable defects for which a scaling deduction was made.

Table 3.--Recovery of lumber by grade from Black Hills ponderosa pine (dry-finished basis)

IMPROVED LOG GRADE 2

Log diameter (Inches)	Logs	Select			Moulding	Factory select	No. 1 shop	Common			
		B	C	D				1 & 2	3	4	[1]5
	No.	Percent									
ALL LOGS											
8	1	0	0	18.1	12.0	0	0	48.2	21.7	0	0
9	0	0	0	0	0	0	0	0	0	0	0
10	1	0	13.1	20.6	0	0	0	66.3	0	0	0
11	5	2.2	2.2	13.9	0	0	0	60.3	16.6	4.8	0
12	4	.6	7.1	17.3	0	2.4	0	42.9	19.7	10.0	0
13	9	0	6.4	15.4	0	.4	2.8	28.0	32.5	14.2	.3
14	10	2.6	16.5	19.2	0	.7	0	17.8	32.3	10.3	.6
15	9	.5	11.9	18.6	0	0	2.9	20.5	26.9	17.7	1.0
16	6	3.9	14.9	20.2	.9	2.6	1.0	22.8	22.1	11.0	.6
17	4	1.8	7.9	13.4	0	1.5	6.4	17.4	38.8	12.4	.4
18	7	2.4	11.0	21.5	1.0	1.0	2.0	18.7	23.9	18.3	.2
19	11	1.7	12.3	19.5	2.0	1.8	4.5	11.0	23.3	21.8	2.1
20	5	.4	7.6	18.9	.4	1.7	13.0	7.9	22.1	22.5	5.5
21	11	2.3	11.8	21.6	1.6	3.5	12.2	7.7	15.7	22.6	1.0
22	5	0	17.9	22.8	0	1.0	3.8	3.2	13.7	32.6	5.0
23	7	3.2	13.2	21.2	2.0	1.9	7.5	5.7	19.8	22.5	3.0
24	4	2.2	12.4	22.8	0	2.2	20.5	0	11.3	20.3	8.3
25	2	0	1.6	14.9	0	2.2	9.8	0	53.4	18.1	0
26	1	0	8.4	30.4	0	0	5.1	3.1	19.2	32.8	0
27	1	0	18.1	22.8	0	26.2	6.7	4.5	8.6	12.4	.7
Total	103										
ALL FULL-SCALE LOGS[2]											
8	1	0	0	18.1	12.0	0	0	48.2	21.7	0	0
9	0	0	0	0	0	0	0	0	0	0	0
10	1	0	13.1	20.6	0	0	0	66.3	0	0	0
11	3	3.3	.9	15.0	0	0	0	60.1	20.7	0	0
12	2	0	11.5	19.9	0	4.5	0	32.1	19.0	13.0	0
13	3	0	4.7	25.1	0	1.3	7.4	34.7	22.9	3.9	0
14	4	2.4	18.4	19.7	0	0	0	20.0	33.1	6.4	0
15	4	1.1	14.3	18.7	0	0	3.3	19.3	19.3	24.0	0
16	1	3.7	11.2	17.9	0	7.7	0	49.3	10.2	0	0
17	2	1.6	13.5	13.9	0	.7	7.4	23.5	33.3	6.1	0
18	2	0	10.4	19.4	0	2.2	0	41.4	22.2	4.4	0
19	4	1.5	10.7	17.1	.8	1.7	6.5	16.1	23.6	19.0	3.0
20	2	0	4.7	9.0	0	1.7	23.5	14.4	21.4	17.5	7.8
21	5	1.9	13.3	16.3	2.4	4.5	14.6	8.0	12.3	25.5	1.2
22	0	0	0	0	0	0	0	0	0	0	0
23	1	2.9	16.2	16.2	0	0	0	9.4	42.4	12.9	0
24	1	6.5	16.6	10.8	0	2.0	37.7	0	0	6.7	19.7
25	0	0	0	0	0	0	0	0	0	0	0
26	1	0	8.4	30.4	0	0	5.7	3.1	19.6	32.8	0
Total	37										
ALL PARTIAL-SCALE LOGS[3]											
11	2	0	5.1	11.5	0	0	0	60.4	8.0	15.0	0
12	2	1.4	2.4	14.5	0	0	0	54.7	20.4	6.6	0
13	6	0	7.2	10.7	0	0	.6	24.7	37.2	19.2	.4
14	6	2.8	14.7	18.8	0	1.4	0	15.7	31.5	13.9	1.2
15	5	0	9.6	18.4	0	0	2.5	21.8	34.2	11.6	1.9
16	5	3.9	16.0	20.9	1.2	1.0	1.3	14.8	25.7	14.4	.8
17	2	2.0	1.2	12.9	0	2.4	5.3	10.1	45.3	19.9	.9
18	5	3.8	11.3	22.6	1.6	.4	3.2	5.5	24.9	26.5	.2
19	7	1.8	13.7	21.7	3.2	1.9	2.6	6.4	23.0	24.3	1.4
20	3	.8	9.9	26.9	.7	1.8	4.6	2.6	22.7	26.4	3.6
21	6	2.7	10.1	27.1	.6	2.4	9.8	7.4	19.4	19.6	.9
22	5	0	17.9	22.8	0	1.0	3.8	3.2	13.7	32.6	5.0
23	6	3.3	0	22.5	2.5	2.3	9.5	4.8	13.9	25.0	3.8
24	3	.6	0	27.2	0	2.2	14.3	0	15.5	25.2	4.1
25	2	0	0	14.9	0	2.2	9.8	0	53.4	18.1	0
26	0	0	0	0	0	0	0	0	0	0	0
27	1	0	18.1	22.8	0	26.2	6.7	4.5	8.6	12.4	.7
Total	66										

[1] Volume derived from downgrade of higher grades.
[2] Logs free of any scalable defects.
[3] Logs with scalable defects for which a scaling deduction was made.

Table 4.--Recovery of lumber by grade from Black Hills ponderosa pine (dry-finished basis)
IMPROVED LOG GRADE 3

Log diameter (Inches)	Log	Select B	Select C	Select D	Moulding	Factory select	No. 1 shop	Common 1 & 2	Common 3	Common 4	Common 5[1]
	No.	Percent									
ALL LOGS											
8	2	0	0	0	0	0	0	73.7	26.3	0	0
9	9	0	1.3	9.9	0	0	3.4	52.9	10.7	17.9	3.9
10	16	.2	3.1	8.1	0	.5	2.3	44.5	29.0	11.1	1.2
11	25	.5	3.4	4.8	0	.5	1.4	49.3	22.9	17.1	.1
12	20	0	5.7	9.6	.4	0	2.6	40.8	31.1	8.9	.9
13	28	.5	4.7	8.8	0	1.0	1.0	31.5	33.5	17.6	1.4
14	24	.6	3.6	8.4	.2	.6	3.5	39.6	27.6	15.6	.3
15	26	.6	5.5	11.6	0	1.1	2.6	29.0	30.0	19.3	.3
16	18	.5	10.2	10.3	.3	2.9	4.7	23.8	28.2	18.0	1.1
17	22	.3	4.7	11.7	.4	3.1	7.8	19.7	26.1	23.4	2.8
18	18	.8	4.7	11.0	.2	5.1	10.2	11.0	26.7	26.9	3.4
19	14	1.0	3.0	13.1	0	6.2	13.2	7.8	25.4	27.7	2.6
20	9	0	6.2	6.9	.7	4.2	17.3	8.7	20.7	29.7	5.6
21	16	.3	4.2	8.3	0	4.3	17.1	4.7	21.2	35.4	4.5
22	9	.4	4.9	10.2	.9	5.7	13.0	5.0	25.3	26.3	8.3
23	7	.9	8.0	11.9	0	4.7	10.9	4.0	19.6	38.4	1.6
24	6	.9	6.3	17.0	0	4.7	15.7	1.8	19.7	26.3	7.6
25	2	1.0	8.3	18.4	0	1.2	12.7	0	10.4	41.2	6.8
26	4	1.2	8.9	9.7	1.6	9.3	21.5	2.0	16.3	25.2	4.3
27	1	0	5.1	2.6	0	5.0	14.9	1.3	22.8	39.1	8.7
28	0	0	0	0	0	0	0	0	0	0	0
29	2	1.2	16.3	21.2	0	.4	8.6	2.7	9.6	37.9	2.2
30	0	0	0	0	0	0	0	0	0	0	0
31	1	0	2.6	6.0	0	4.7	14.9	3.0	.6	57.0	11.2
Total	279										
ALL FULL-SCALE LOGS[2]											
8	1	0	0	0	0	0	0	84.9	15.1	0	0
9	4	0	1.0	13.6	0	0	0	36.6	14.4	26.8	7.6
10	8	0	3.2	11.1	0	0	2.9	45.2	21.9	14.8	.9
11	17	.2	3.4	4.8	0	.6	1.0	55.2	25.2	9.4	.2
12	8	0	6.5	11.8	0	0	2.0	51.8	23.4	4.5	0
13	15	.4	5.2	7.9	0	1.0	.6	37.4	33.2	14.1	.2
14	14	.6	4.2	7.6	.3	0	4.1	39.8	25.6	17.8	0
15	10	.5	3.4	9.3	0	2.1	2.8	41.4	29.2	11.3	0
16	8	.5	9.6	8.8	.5	2.2	3.4	34.5	28.9	11.6	0
17	11	.4	6.0	14.6	.2	1.8	4.7	27.1	27.0	15.5	2.7
18	2	1.4	4.4	15.0	0	0	6.0	9.1	31.7	32.4	0
19	7	1.6	3.9	13.3	0	7.9	11.5	9.5	32.0	19.4	.9
20	3	0	7.1	11.9	0	.9	20.1	10.3	22.1	19.3	8.3
21	3	0	4.6	6.9	0	3.6	22.0	5.0	35.9	22.0	0
22	4	.4	4.3	9.2	0	3.4	16.7	8.1	28.8	21.9	7.2
23	2	0	5.9	11.6	0	6.0	13.0	1.2	25.8	35.6	.9
24	1	0	1.8	3.1	0	15.6	36.3	0	18.6	24.6	0
25	1	0	1.1	9.9	0	0	13.8	0	14.2	56.1	4.9
26	1	0	4.4	5.5	0	8.7	24.6	1.8	33.4	16.8	4.8
Total	120										
ALL PARTIAL-SCALE LOGS[3]											
8	1	0	0	0	0	0	0	57.6	42.4	0	0
9	5	0	1.7	5.9	0	0	7.0	70.4	6.8	8.2	0
10	8	.6	2.8	4.1	0	1.2	1.4	43.7	38.5	6.2	1.5
11	8	1.3	3.3	4.8	0	0	2.6	33.2	16.8	38.0	0
12	12	0	5.1	7.7	.7	0	3.1	30.9	37.9	12.9	1.7
13	13	.7	3.9	10.3	0	1.0	1.5	21.4	33.9	23.8	3.5
14	10	.5	2.5	10.0	0	1.7	2.4	39.3	31.7	11.1	.8
15	16	.6	7.1	13.5	0	.4	2.5	19.0	30.6	25.7	.6
16	10	.5	10.8	12.0	0	3.6	6.1	12.2	27.6	24.9	2.3
17	11	.2	3.1	7.9	.6	4.8	11.7	10.3	24.9	33.5	3.0
18	16	.7	4.7	10.4	.2	6.0	10.9	11.3	25.8	26.0	4.0
19	7	0	1.8	12.7	0	3.7	15.8	5.1	15.7	40.1	5.1
20	6	0	5.4	3.3	1.2	6.6	15.4	7.5	19.8	37.2	3.6
21	13	.4	4.0	8.7	0	4.5	15.8	4.7	17.2	39.0	5.7
22	5	.4	5.7	11.3	2.0	8.4	8.5	1.3	21.0	31.6	9.8
23	5	1.3	8.9	12.1	0	4.2	9.9	5.2	16.9	39.7	1.8
24	5	1.1	7.6	21.1	0	1.5	9.6	2.4	20.0	26.8	9.9
25	1	2.0	16.5	28.1	0	2.5	11.5	0	6.1	24.3	9.0
26	3	1.8	11.3	11.7	2.5	9.6	19.8	2.1	7.5	29.6	4.1
27	1	0	5.6	2.6	0	5.0	14.9	1.3	22.8	39.1	8.7
28	0	0	0	0	0	0	0	0	0	0	0
29	2	1.2	16.3	21.2	0	.4	8.6	2.7	9.6	37.8	2.2
30	0	0	0	0	0	0	0	0	0	0	0
31	1	0	2.6	6.0	0	4.7	14.9	3.0	.6	57.0	11.2
Total	159										

[1] Volume derived from downgrade of higher grades.
[2] Logs free of any scalable defect.
[3] Logs with scalable defects for which a scaling deduction was made.

Table 5.--Recovery of lumber by grade from Black Hills ponderosa pine (dry-finished basis)
IMPROVED LOG GRADE 5

Log diameter (Inches)	Log	Select B	Select C	Select D	Moulding	Factory select	No. 1 shop	Common 1 & 2	Common 3	Common 4	Common 5[1]
	No.	Percent									
					ALL LOGS						
7	57	0.3	1.3	0.8	0	0	0.8	38.8	37.3	18.4	2.3
8	198	.1	1.3	1.1	.1	.1	1.7	36.6	40.1	17.4	1.5
9	133	0	.3	1.9	0	.4	.5	35.4	40.2	18.9	2.4
10	143	.2	.8	1.8	0	.2	.8	36.2	38.1	20.5	1.4
11	110	.1	.6	1.4	0	.2	1.0	29.6	41.0	24.9	1.2
12	103	.1	1.0	2.8	0	.1	1.4	28.3	39.4	25.1	1.8
13	60	.1	1.6	3.1	.1	.2	2.3	26.5	38.6	26.2	1.3
14	44	.1	1.1	4.5	0	1.0	4.0	16.8	38.1	32.6	1.8
15	47	.1	1.0	2.3	.1	2.3	6.3	18.6	34.7	31.5	3.1
16	35	.2	.9	3.3	0	1.3	8.6	13.9	25.7	40.3	5.8
17	27	.1	1.2	2.0	0	2.7	10.0	8.2	26.3	43.8	5.7
18	21	.2	.6	2.3	0	4.1	14.2	6.8	27.1	37.1	7.6
19	19	0	.1	1.7	0	1.7	13.4	10.7	23.2	42.4	6.8
20	17	0	.5	3.2	0	4.5	19.0	3.9	24.0	39.9	5.0
21	5	.4	1.4	1.4	0	4.4	17.6	9.7	24.6	29.3	11.2
22	8	0	.7	4.4	0	3.7	16.9	1.0	19.9	43.7	9.7
23	9	.1	1.6	3.4	.3	6.8	21.5	3.8	24.0	31.2	7.3
24	4	0	1.6	4.4	0	6.8	22.3	0	1.8	48.7	15.6
25	0	0	0	0	0	0	0	0	0	0	0
26	1	0	0	1.5	0	10.3	35.2	0	7.8	43.3	1.9
27	2	0	1.6	9.7	0	.7	34.4	1.4	12.2	30.0	10.0
Total	1,043										
					ALL FULL-SCALE LOGS[2]						
7	54	.3	1.3	.9	0	0	.8	40.7	36.2	18.1	1.7
8	176	.1	1.1	.9	.1	.1	1.4	39.0	39.2	16.5	1.6
9	109	0	.3	1.8	0	.3	.6	38.3	40.6	16.3	1.8
10	105	0	.7	2.0	0	.2	.7	40.2	38.1	16.9	1.2
11	73	.1	.3	1.0	0	.1	.9	33.6	43.1	20.2	.7
12	61	.1	.9	2.9	0	0	1.3	35.8	39.0	19.3	.7
13	34	.1	1.3	3.0	0	.3	2.2	29.7	40.6	22.3	.5
14	25	.1	.9	4.4	0	1.2	3.4	21.2	42.3	26.0	.5
15	17	0	.6	1.4	0	1.2	5.3	27.0	43.4	20.9	.2
16	13	.1	1.0	2.4	0	2.0	7.4	24.6	36.7	22.5	3.3
17	10	.1	1.0	1.0	0	.8	10.2	8.7	30.2	42.9	5.1
18	7	.4	.6	2.0	0	4.7	15.3	10.5	31.1	32.1	3.3
19	4	0	0	1.8	0	3.2	15.4	16.6	20.4	38.3	4.3
20	11	0	.1	1.4	0	5.1	19.9	2.9	22.9	42.7	5.0
21	1	0	0	3.8	0	12.6	13.2	0	15.5	48.2	6.7
22	4	0	0	1.7	0	2.1	13.5	.4	23.4	47.9	11.0
23	2	0	2.5	.7	0	12.3	28.9	5.4	26.3	22.4	1.5
Total	706										
					ALL PARTIAL-SCALE LOGS[3]						
7	3	0	0	0	0	0	0	8.0	56.4	23.8	11.8
8	22	0	2.7	2.2	0	0	4.3	18.4	47.6	23.9	.9
9	24	0	.3	2.1	0	1.0	0	20.2	38.2	32.3	5.9
10	38	.8	1.2	1.0	0	.4	1.0	22.0	38.3	33.2	2.1
11	37	.1	1.6	2.3	0	.4	1.5	19.2	35.7	36.9	2.3
12	42	.1	1.3	2.6	0	.4	1.6	12.7	39.9	37.3	4.1
13	26	.3	2.0	3.4	.4	0	2.5	20.7	35.0	33.0	2.7
14	19	.1	1.6	4.5	0	.8	5.1	9.0	30.7	44.2	4.0
15	30	.2	1.4	3.1	.1	3.2	7.2	11.3	27.2	40.7	5.6
16	22	.3	.8	4.2	0	.7	9.7	3.8	15.1	57.3	8.1
17	17	0	1.5	3.0	0	4.5	9.7	7.8	22.6	44.7	6.2
18	14	0	.6	2.5	0	3.6	13.3	4.1	24.1	40.9	10.9
19	15	0	.2	1.7	0	1.1	12.6	8.3	24.3	44.0	7.8
20	6	0	1.7	9.8	0	2.8	15.7	7.6	28.0	29.7	4.7
21	4	.5	1.8	.7	0	2.1	18.8	12.5	27.2	23.8	12.6
22	4	0	1.6	7.8	0	5.6	21.1	1.8	15.5	38.5	8.1
23	7	.2	1.1	4.8	.4	4.1	17.7	2.9	22.8	35.7	10.3
24	4	0	1.6	4.4	0	6.8	22.3	0	1.8	48.7	15.6
25	0	0	0	0	0	0	0	0	0	0	0
26	1	0	0	1.5	0	10.3	35.2	0	7.8	43.3	1.9
27	2	0	1.6	9.7	0	.7	34.4	1.4	12.2	30.0	10.0
Total	337										

[1] Volume derived from downgrade of higher grades.
[2] Logs free of any scalable defects.
[3] Logs with scalable defects for which a scaling deduction was made.

was 160,393.3 bd. ft. The corresponding volume of rough-dry lumber was 152,441.0, and the volume of finished-dry lumber was 146,444.3. Thus 7,952.3 bd. ft. (about 5 percent) was lost during seasoning, and 5,996.7 bd. ft. (about 3.7 percent) was lost during surfacing. These are not unusual losses for the lumber grades involved.

A high proportion of the volume losses were due to breakage caused largely by compression wood and spiral grain. Decay also was an important factor; boards with considerable decay broke up during drying. Tables 6 and 7 compare the grade changes that theoretically resulted from surfacing; some of the differences, however, may also be due to the fact that grading defects were easier to see after surfacing. In general, the differences are quite minor, and indicate consistent lumber grading.

It was not feasible to determine grade changes during seasoning, since the green lumber was not graded except as necessary for sorting for seasoning and to discard the unmerchantable green 5 common.

Sawing Accuracy

About 100 boards in each width class were randomly selected in the rough-green and measured to determine accuracy. Unusually high or low yields that might result from cutting inaccuracies could thus be identified. Boards from both the head saw and the cant gang saw were included.

Thickness and width measurements were taken on the sample boards at midpoint and 2 feet from each end. The thickness measurement was read to the nearest 1/32 inch while the width was taken to the nearest 1/8 inch. Thickness measurements were alternated to sample both edges.

The sawing accuracy was found to be good for both thickness and width, and generally well within Western Wood Products Association's prescribed standards of 30/32-36/32 inches. The few boards that fell outside this specified range were of no consequence to total volume recovery.

Most variation was found in the boards sawed on the circular head saw, where the major portion was found to range between 34/32 and 35/32 inches. Most of the boards sawed on the cant gang ranged between 31/32 and 32/32 inches. Since the head-saw boards and cant widths were controlled at the head saw, no comparison by width by saw type was attempted.

Lumber Volume and Overrun

The volume of lumber actually recovered was compared with the volume estimated by log scale (table 8). Such a comparison would help to identify reasons for any major differences between the estimated log volume and the actual lumber volume. All lumber volumes shown are based on dry finished condition, and represent actual unsmoothed volumes. The volumes shown do not provide for possible additional losses that occur in yard handling and storage.

In general, the overrun values, by 1-inch log diameter classes, followed the same general pattern as that for 1-inch tree diameter classes (see table 1). The variation among log classes was found to be somewhat greater, however, because of the closer grouping that the log diameters provide. For example, a 10-inch tree diameter class includes 7-, 8-, and possibly 9-inch diameter logs, whereas a 10-inch log diameter class is limited to 10-inch logs. As generally follows in studies of this type, the presence of scalable defect tended to increase the overrun, which accounts for the higher values in the partial-scale logs. Overrun also tended to increase with log length.

As with the grade recovery data, overrun percentages must be applied by log diameters to be meaningful because of the nature of the sample.

Performance of Log Grades

Shortly before this study was planned, an improved set of ponderosa pine log grades was developed.[9] The improved grades, based partly on the data collected from Black Hills timber in an earlier study,[10] had not been field tested on Black Hills ponderosa pine. The third objective of this study was to evaluate these new log grades.

Both the old and the new systems were used to grade the study logs before felling, after felling, and again after the logs were brought to the yard. Woods grading was done

[9] *See footnote 3, p. 1.*
[10] *See footnote 8, p. 8.*

Table 6. --Surfaced-dry volume by lumber grade and log diameter -- all logs

Log diameter (Inches)	Select			Moulding	Factory select	No. 1 shop	Common				Total
	B	C	D				1 & 2	3	4	[1] 5	
						Percent					
7	0.3	1.3	0.8	0.1	0	0.8	38.8	37.3	18.4	2.3	100.0
8	.1	1.3	1.1	0	.1	1.7	37.0	40.1	17.0	1.5	100.0
9	0	.4	2.4	0	.3	.7	36.5	38.5	18.7	2.5	100.0
10	.2	1.1	2.5	0	.3	.9	37.2	37.0	19.5	1.3	100.0
11	.2	1.2	2.4	0	.2	1.1	34.1	37.0	22.8	1.0	100.0
12	.1	2.0	4.6	.1	.2	1.5	30.7	37.1	22.1	1.6	100.0
13	.3	2.9	6.2	.1	.5	2.0	27.9	36.2	22.6	1.3	100.0
14	.5	4.0	8.1	.1	.8	3.3	23.5	34.3	24.2	1.2	100.0
15	.3	4.2	8.5	.1	1.6	4.5	21.7	31.3	25.9	1.9	100.0
16	.7	6.1	8.1	.2	1.9	6.3	17.8	25.9	29.5	3.5	100.0
17	.4	5.1	8.8	.2	2.6	8.2	14.8	26.0	30.3	3.6	100.0
18	.8	5.1	9.9	.2	3.7	9.9	10.9	25.9	29.2	4.4	100.0
19	.8	5.5	11.1	.5	3.2	10.5	10.3	23.1	30.9	4.1	100.0
20	.7	4.5	7.6	.3	3.8	16.3	6.1	22.0	33.4	5.3	100.0
21	1.4	7.1	11.9	.5	3.9	15.2	6.4	19.0	30.2	4.4	100.0
22	1.0	8.3	12.6	.9	3.9	11.1	3.0	20.6	31.4	7.2	100.0
23	1.3	8.8	12.8	.6	4.4	13.0	4.1	20.9	30.3	3.8	100.0
24	1.0	9.0	19.3	0	3.7	16.1	1.5	11.6	29.6	8.2	100.0
25	1.4	9.3	17.4	0	2.1	9.0	.5	26.9	30.0	3.4	100.0
26	.9	7.7	16.8	.9	5.5	14.7	1.9	19.8	29.5	2.3	100.0
27	0	6.6	10.6	0	7.9	22.1	2.1	14.5	28.7	7.5	100.0
28	0	0	0	0	0	0	0	0	0	0	
29	1.2	16.3	21.2	0	.4	8.6	2.7	9.6	37.8	2.2	100.0
30	0	0	0	0	0	0	0	0	0	0	
31	0	2.6	6.0	0	4.7	14.9	3.0	.6	57.0	11.2	100.0

[1] Volumes shown derived from grade losses in higher grades.

Table 7. --Rough-dry volume by lumber grade and log diameter -- all logs

Log diameter (Inches)	Select			Moulding	Factory select	No. 1 shop	Common				Total
	B	C	D				1 & 2	3	4	[1] 5	
						Percent					
7	0	0.5	1.3	0.4	0	0	30.2	48.7	17.8	1.1	100.0
8	.1	.3	1.2	.1	.5	1.3	31.7	46.3	17.8	.7	100.0
9	0	.3	1.7	0	.3	.1	33.1	46.2	17.0	1.3	100.0
10	.1	.9	2.7	.1	0	.4	34.5	37.5	23.0	.8	100.0
11	.1	.8	3.3	.2	.1	.5	36.4	24.8	32.6	1.2	100.0
12	.2	1.3	5.1	.1	.1	1.2	33.6	23.2	33.2	2.0	100.0
13	.2	2.6	5.7	.2	.5	2.2	31.3	25.3	30.5	1.5	100.0
14	.2	3.7	8.7	.1	.6	3.5	28.6	22.2	30.4	2.0	100.0
15	.3	3.7	9.2	.2	1.1	4.8	23.9	25.8	28.7	2.3	100.0
16	.6	4.6	9.0	.2	1.3	6.6	20.8	25.6	27.8	3.5	100.0
17	.3	4.8	9.9	.2	3.4	8.1	18.5	29.4	24.0	1.4	100.0
18	.8	4.7	9.5	.3	4.2	10.0	14.2	30.6	24.1	1.6	100.0
19	.7	6.4	11.4	.1	3.1	10.2	14.1	26.1	26.2	1.7	100.0
20	1.0	5.3	6.7	.1	5.1	15.0	8.6	28.2	27.6	2.4	100.0
21	1.2	7.5	12.9	.1	5.0	14.0	8.6	24.7	22.8	3.2	100.0
22	.8	8.7	13.2	.4	5.9	9.8	4.3	25.5	28.6	2.8	100.0
23	1.7	8.0	13.8	.3	6.1	11.5	6.7	19.8	26.0	6.1	100.0
24	1.6	9.8	16.7	.6	5.4	15.8	3.1	14.4	25.2	7.4	100.0
25	2.5	11.4	14.3	.3	2.7	9.9	.4	11.3	43.5	3.7	100.0
26	1.1	8.4	17.2	.5	6.8	10.9	2.5	13.3	30.0	9.3	100.0
27	.5	4.6	10.3	0	8.0	21.3	.5	9.6	28.9	16.3	100.0
28	0	0	0	0	0	0	0	0	0	0	
29	4.1	14.3	22.7	0	1.1	9.6	3.3	9.6	33.6	1.7	100.0
30	0	0	0	0	0	0	0	0	0	0	
31	.6	2.4	2.5	0	1.5	24.2	0	0	37.7	31.1	100.0

[1] Volumes shown derived from grade losses in higher grades.

Table 8. --Average volume of lumber recovery from Black Hills ponderosa pine (dry-finished basis)

Log diameter (Inches)	Full-scale logs[1]					Partial-scale logs[4]					All logs				
	Logs	Log scale[2]		Lumber recovery	Overrun[3] or underrun	Logs	Log scale[2]		Lumber recovery	Overrun[3] or underrun	Logs	Log scale[2]		Lumber recovery	Overrun[3] or underrun
		Gross	Net				Gross	Net				Gross	Net		
	No.	Board feet			Percent	No.	Board feet			Percent	No.	Board feet			Percent
							ALL LOGS								
7 & 8	233	22	22	29.7	35.0	26	29	18	31.5	75.0	259	23	22	29.9	35.9
9	113	37	37	44.1	19.2	30	38	28	37.7	34.6	143	37	35	42.7	22.0
10	114	54	54	60.5	12.0	46	53	38	46.7	22.9	160	54	50	56.5	13.0
11	93	67	67	74.6	11.3	47	67	50	57.3	14.6	140	67	61	68.8	12.8
12	71	77	77	92.5	20.1	58	75	59	65.8	11.5	129	76	69	80.5	16.7
13	53	98	98	105.8	8.0	47	93	67	77.1	15.1	100	96	83	92.3	11.2
14	43	109	109	126.9	16.4	39	104	84	90.6	7.8	82	107	97	109.6	13.0
15	32	136	136	147.1	8.2	55	134	105	108.0	2.8	87	135	116	122.4	5.5
16	23	156	156	164.7	5.6	38	154	114	109.5	-4.0	61	155	130	130.3	.2
17	24	178	178	192.1	7.9	33	171	133	136.5	2.6	57	174	152	159.9	5.2
18	12	210	210	221.8	5.6	38	201	165	157.4	-4.6	50	203	176	172.8	-1.8
19	15	240	240	250.6	4.4	32	236	182	167.5	-8.0	47	237	201	194.0	-3.5
20	16	266	266	265.6	-0.2	17	274	217	188.0	-13.4	33	270	241	225.6	-6.4
21	10	300	300	275.6	-8.1	23	297	255	224.6	-11.9	33	298	269	240.0	-10.8
22	9	330	330	304.8	-7.6	16	322	258	235.9	-8.6	25	325	284	260.7	-8.2
23	5	380	380	352.3	-7.3	20	363	292	241.1	-17.4	25	366	310	263.3	-15.1
24	3	383	383	344.7	-10.0	14	396	275	243.0	-11.6	17	394	294	261.0	-11.2
25	1	460	460	367.4	-20.1	4	460	390	316.7	-18.8	5	460	404	326.8	-19.1
26	2	470	470	410.4	-12.7	6	500	417	327.2	-21.5	8	492	430	348.0	-19.1
27	0	0	0	0	0	4	550	482	319.1	-33.8	4	550	482	319.1	-33.8
29	0	0	0	0	0	2	610	585	465.0	-20.5	2	610	585	465.0	-20.5
31	0	0	0	0	0	1	710	670	311.0	-53.6	1	710	670	311.0	-53.6
Total	872					596					1,468				
							16-FOOT LOGS								
7 & 8	94	30	30	36.7	22.3	23	30	18	32.0	77.8	117	30	28	35.8	27.8
9	82	40	40	49.7	24.2	25	40	30	38.5	28.3	107	40	38	47.0	23.7
10	91	60	60	65.8	9.7	35	60	44	51.2	16.4	126	60	56	61.7	10.2
11	83	70	70	77.4	10.6	42	70	53	60.2	13.4	125	70	64	71.6	11.9
12	64	80	80	96.5	20.6	48	80	62	69.9	12.7	112	80	72	85.1	18.2
13	50	100	100	108.4	8.4	38	100	72	84.7	17.6	88	100	88	98.2	11.6
14	41	110	110	129.2	17.5	31	110	91	101.8	11.9	72	110	102	117.4	15.1
15	28	140	140	153.1	9.4	49	140	110	114.2	3.8	77	140	121	128.3	6.0
16	22	160	160	168.2	5.1	33	160	123	117.5	-4.5	55	160	138	137.8	-.2
17	23	180	180	196.4	9.1	27	180	143	147.9	3.4	50	180	160	170.2	6.4
18	12	210	210	221.8	5.6	33	210	172	164.3	-4.5	45	210	182	179.6	-1.3
19	15	240	240	250.6	4.4	30	240	184	170.0	-7.6	45	240	203	196.9	-3.0
20	13	280	280	273.2	-2.4	16	280	222	194.9	-12.2	29	280	248	230.0	-7.3
21	10	300	300	275.6	-8.1	22	300	257	223.7	-13.0	32	300	270	239.9	-11.1
22	9	330	330	304.8	-7.6	14	330	263	234.2	-11.0	23	330	289	261.8	-9.4
23	5	380	380	352.3	-7.3	17	380	303	242.9	-19.8	22	380	320	267.8	-16.3
24	2	400	400	339.0	-15.2	13	400	271	238.7	-11.9	15	400	288	252.1	-12.5
25	1	460	460	367.4	-20.1	4	460	390	324.8	-16.7	5	460	404	333.3	-17.5
26	1	500	500	450.6	-9.9	6	500	417	327.2	-21.5	7	500	429	344.8	-19.6
27	0	0	0	0	0	4	550	482	319.1	-33.8	4	550	482	319.1	-33.8
29	0	0	0	0	0	2	610	585	465.0	-20.5	2	610	585	465.0	-20.5
31	0	0	0	0	0	1	710	670	311.0	-53.6	1	710	670	311.0	-53.6
Total	646					513					1,159				
							14-FOOT LOGS AND UNDER								
7 & 8	139	17	17	24.9	46.5	3	20	10	27.5	127.5	142	17	17	25.0	47.1
9	31	28	28	29.3	4.6	5	30	20	33.9	69.5	36	28	27	29.9	10.7
10	23	32	32	39.7	24.1	11	33	20	32.2	61.0	34	32	28	37.3	33.2
11	10	41	41	51.4	25.4	5	42	26	32.9	26.5	15	41	36	45.2	25.6
12	7	50	50	55.6	11.2	10	55	42	46.0	9.5	17	53	45	50.0	11.1
13	3	60	60	61.9	3.2	9	63	46	45.2	-1.7	12	62	50	49.4	-1.2
14	2	80	80	79.2	1.0	8	81	59	46.9	-20.5	10	81	63	53.4	-15.2
15	4	105	105	105.6	.6	6	85	67	57.4	-14.3	10	93	82	76.7	-6.5
16	1	80	80	89.2	11.5	5	112	60	56.7	-5.5	6	107	63	62.1	-1.4
17	1	140	140	93.0	-33.6	6	132	87	85.1	-2.2	7	133	95	86.2	-9.3
18	0	0	0	0	0	5	144	122	111.3	-8.8	5	144	122	111.3	-8.8
19	0	0	0	0	0	2	180	135	130.1	-3.6	2	180	135	130.1	-3.6
20	3	207	207	232.8	12.5	1	170	130	77.4	-40.5	4	198	188	193.9	3.1
21	0	0	0	0	0	1	230	210	245.0	16.7	1	230	210	245.0	16.7
22	0	0	0	0	0	2	270	225	247.8	10.1	2	270	225	247.8	10.1
23	0	0	0	0	0	3	267	227	231.1	1.8	3	267	227	231.1	1.8
24	1	350	350	355.9	1.7	1	350	330	299.1	-9.4	2	350	340	327.5	-3.7
25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26	1	440	440	370.2	-15.9	0	0	0	0	0	1	440	440	370.2	-15.9
Total	226					83					309				

[1] Logs free of any scalable defects.
[2] Scribner Decimal "C" Log Scale.
[3] Difference in volume between net log scale and finished lumber tally.
[4] Logs with scalable defects for which a scale deduction was made.

by the three-man selection team. The yard grading was done by the Forest Service check grader for western softwoods. Thus it was possible to compare the two systems for accuracy, and for ease and consistency of application by individuals with different training and experience. The grade and value separation provided by the two grading systems is summarized in table 9.

The spread in value per M bd. ft. based on volume of finished lumber recovered is a convenient means of determining the effectiveness of a grading system. While no exact values have been established for what might be the desired spread in value between grades, $10 per M generally has been considered as about the minimum separation. Ruling out grade 4 because of the inadequacy of the sample, both systems appear to meet this requirement. The major difference between the two grading systems, and the feature that best demonstrates the greater effectiveness of the improved grades, is the better segregation of logs that resulted. This was most pronounced in grade 2, where the number of logs was more than doubled with only a relatively minor decrease in value per M.

The relatively few logs in the old grade 6 support the validity of dropping this category and converting to the improved five-grade system. Those doing the woods and yard grading for this study generally agreed that the improved grades were easier to understand and to use consistently.

A brief analysis was made to determine the relationship of the grade of the butt log of the sample trees to the total value of the tree (table 10). This was done to see if perhaps grading the butt log only offered any promise as a tree grading system. The analysis also provided information on the number of trees by grade of butt log and the value per M and total for each quality class as well as for the total sample.

The standard error shown for the various quality classes considered indicates the within-grade range of values that the classification provided. While these may be too large for a refined segregation, especially in the case of log grades 1 and 2, the system does appear to offer promise, particularly in view of its simplicity. The overall per M value of $80.59 is approximately $5 above the average found on actual timber sales in the area.

Performance of Revised Scaling Method

The revised Forest Service scaling procedure was compared to the method commonly used

Table 9.--Comparison of performance of Improved Ponderosa Pine Log Grades with Pacific Northwest Log Grades, Black Hills ponderosa pine

Log grade	Logs	Select B	Select C	Select D	Moulding	Factory select	No. 1 shop	Common 1 & 2	Common 3	Common 4	Common 5	Value[1] per M
	No.	Percent										Dollars
Pacific Northwest Grades:												
1	40	3.2	18.8	25.8	0.6	1.0	1.7	9.1	15.4	23.0	1.4	108.34
2	50	1.8	13.6	21.2	1.5	2.1	5.5	9.6	22.3	19.6	2.8	99.42
3	259	.9	7.3	13.7	.3	2.8	8.5	17.6	23.5	22.9	2.5	87.10
4	2	0	0	0	0	0	0	35.5	64.5	0	0	76.26
5	1,106	.1	1.1	2.9	0	1.8	6.7	22.1	33.1	28.7	3.5	71.38
6	11	0	.8	.8	0	1.7	13.2	1.9	27.3	47.4	6.9	60.48
Total	1,468											
Improved Grades:												
1	41	3.2	19.1	26.3	.7	1.1	1.7	9.4	15.4	21.7	1.4	109.41
2	103	1.7	11.6	20.1	.8	2.1	6.9	12.6	22.4	19.6	2.2	96.67
3	279	.6	5.6	10.5	.2	3.3	9.2	18.3	24.5	24.8	3.0	82.49
4	2	0	0	0	0	0	0	35.5	64.5	0	0	76.26
5	1,043	.1	.9	2.5	0	1.5	6.3	22.2	33.8	29.2	3.5	70.75
Total	1,468											

[1] Based on 1962 lumber prices.

Table 10.--Relationship of grade of butt log[1] of sample tree to total value[2] of tree

Log grade of butt log	Trees	Volume	Total value	Value per M	Standard error
	No.	Bd.ft.	- - - Dollars	- - -	
1	40	18,885.3	1,743.75	92.33	±13.76
2	93	38,716.7	3,280.46	84.73	±8.76
3	176	58,521.4	4,539.27	77.57	±6.29
4	0	0	0	0	0
5	183	30,260.1	2,237.07	73.93	±4.52
Total	[3] 492	146,444.3	11,800.55		

[1] Grade based on Improved Ponderosa Pine Log Grades.
[2] Based on 1962 lumber prices.
[3] Analyses based on 492 trees, because 6 trees were culled in the woods and the logs from 2 other merchantable trees were not brought in to the sawmill.

at the time of the study. The scaler identified the scaling deductions with the type of defects to (1) rank the defects, and (2) determine whether the scaling method varied any by type of defect. Table 11 summarizes the results of the comparison, which is based on the Forest Service net log scale.

The overrun percentages shown relate the volume of finished-dry lumber to the defect class, and reflect the adequacy of the respective scale deductions. Overrun values were computed only for the scaling method that was current at the time. The revised procedure yielded slightly less deductions on certain defects, and therefore would tend to reduce the volume of overrun slightly.

It is evident that red rot is the most serious single defect in Black Hills ponderosa pine. It also was the one commonly found in the multiple defect class.

Weight Scaling

An exploratory study was conducted in conjunction with the main study to determine the feasibility of weight scaling Black Hills ponderosa pine. All truckloads of study logs were identified and weighed as they were delivered to the mill, so that the board foot-weight relations shown in table 12 could be computed.

In general, the results indicated that ponderosa pine can readily be weight scaled. Weight scaling might be considered for the standard scaling method in the Black Hills. As with volume scaling, the presence of defects is a problem, and the success of the method will depend largely on how well proper allowances for defects are applied. The problem is complicated by the fact that certain rots may or may not influence the weight of logs, depending largely on the stage of development. Advanced brown rot or red rot can reduce the weight significantly, whereas they might have little or no effect in the earlier stages. Other factors that can cause some variation in the weight of logs are the seasonal changes in moisture content, and possible moisture losses between felling and weighing. These factors can be compensated for, however, by sample weight scaling at some predetermined interval, or whenever there is evidence of some change in the condition of the logs.

Weight scaling offers the important advantage of eliminating differences in estimated volumes due to variations in determining correct log diameters. Largely because of this, weight

Table 11.--Relation of scaling method and type of defect to log scale[1] and lumber recovery

Type of defect	Logs	Scale in use at time of study			Revised scale			Overrun or underrun[2]
		Gross	Net	Defect	Gross	Net	Defect	
	No.	Board feet		Percent	Board feet		Percent	Percent
Red rot	167	2,069	1,638	20.8	2,080	1,680	19.2	2.5
Other rot	84	1,542	1,202	22.0	1,543	1,225	20.6	-3.0
Fire scar	45	693	556	19.8	695	558	19.7	1.9
Cat face	22	265	227	14.3	269	231	14.1	1.9
Lightning scar	2	35	30	14.3	35	30	14.3	14.4
Crook/sweep	70	530	434	18.1	534	437	18.2	13.1
Crotch/fork	13	84	66	21.4	84	66	21.4	3.5
Checks/splits	14	382	360	5.8	382	360	5.8	-7.4
All other	15	306	279	8.8	306	279	8.8	-12.9
Multiple 2+	164	3,379	2,519	25.3	3,375	2,525	25.2	-13.9
Total	596	9,285	7,311	21.3	9,303	7,391	20.6	

[1] All log scales shown are based on Scribner Decimal "C" scale.
[2] Based on scale method in use at time of study.

scaling can be more rapid, and therefore offer an appreciable saving in timber sale administration.

Summary and Conclusions

Lumber volumes and grade recovery were studied for 1,468 logs cut from 498 Black Hills ponderosa pine trees. The primary purpose of the study was to determine the adequacy of the timber volume estimating procedure in use by the Forest Service, and to develop up-to-date information on the volumes and grades of lumber being produced in the area. The study tested the application of the Improved Ponderosa Pine Log Grades, and investigated the feasibility of weight scaling.

The sample trees were selected to include as many as possible of the log sizes and grades found in the Black Hills to provide volume and grade recovery information for essentially all the trees that might occur in a given sale. Sample tree selection was confined largely to trees that had been previously marked for cutting on sale areas located on 5 of the 10 Ranger Districts of the Black Hills National Forest.

In view of the method of sampling used in the selection of the study trees, the data are representative of the timber by the various diameter and log grade classes as studied, and therefore must be so applied.

Major findings and conclusions were:

1. The timber estimating practices used, especially the net tree volume tables, appeared to be satisfactory within the range of diameters most common to the Black Hills. The predicted net volume determined from the tables was [redacted] bd. ft., compared to 143,110 bd. ft. determined by Forest Service log scale, 136,080 bd. ft. by the Western Wood Products Association scaler, and 147,350 bd. ft. by the woods scale. The total volume of lumber produced, dry finished basis, was 146,440.3 bd. ft.
2. Overrun and underrun values (in the log diameter classes sufficiently well represented to provide reliable data) varied from 36 percent overrun for the smaller logs to 19 percent underrun for the larger ones. The overrun values do not take into account the additional volume losses that occur through normal yard handling and storage.
3. The lumber grade recovery pattern followed the usual distribution characteristic of Black Hills timber, with a high proportion of the volume in the common grades. The data indicate that, for log diameters and grades most typical of the Black Hills—from about 8 to 20 inches in log grades 3 and 5—about three-fourths of the lumber volume can be expected in about equal amounts of grades 1 and 2 common, 3 common, and 4 common, with the balance about equally made up of upper grades and 5 common. The proportion of 5 common in the recovery tables is below average, since it does not include about 5,500 bd. ft. that was discarded in the rough green as unmerchantable. The volume of 5 common shown resulted only from downgrading of the higher grades in the seasoning and surfacing operations.
4. Approximately 1,105 of the 1,725 logs selected, or about 64 percent were defective. The defective logs consisted of 259 culled in the woods, 594 scaled as defective in the yard, and 252 that contained hidden defects not detected by the scaler. This high proportion of defective logs in the sawtimber stands of the Black Hills contributes to the high manufacturing costs that prevail in the area. Also, the relatively high proportion of logs in which the presence of defects is not detectable emphasizes the need of developing improved criteria for this purpose.
5. The milling operation, including the quality of the sawing, seasoning, and surfacing, was found to be high, and in no way biased the results.
6. The Improved Ponderosa Pine Log Grades were generally considered to be better adapted to Black Hills ponderosa pine than the Pacific Northwest Grades.
7. With revised Forest Service scaling method, the scale deduction was decreased about 1 percent over the former system.
8. Results of the weight scaling tests indicated that Black Hills ponderosa pine could be successfully scaled by weight, provided proper allowances were made for scalable defects. Red rot was found to be the most serious defect.

Table 12. --Weight-board foot ratios by sources of logs and percent defect

Log source	Defect			Weight, gross scale			Weight, net scale		
	Minimum	Maximum	Mean	Minimum	Maximum	Mean	Minimum	Maximum	Mean
	- - - Percent - - -			- - - - - - - - - - Pounds per board foot - - - - - - - - - -					
Buck Springs	2.6	19.2	11.7	9.1	13.6	10.9	10.2	15.8	12.3
Herbert	4.3	36.7	18.0	8.9	11.3	9.2	8.9	14.4	11.3
Iron Creek	9.1	17.3	13.7	7.3	12.3	8.9	8.3	13.8	10.3
Higgins Gulch	1.3	20.3	8.9	7.8	15.1	10.2	8.6	13.0	11.3
Golden West	5.1	33.0	18.0	7.5	12.5	9.1	8.7	14.4	11.2
Weighted average						9.40±0.34*			10.99±0.3

*95 percent confidence level.

APPENDIX

IMPROVED SPECIFICATIONS

FOR

PONDEROSA PINE LUMBER LOG GRADES[1]

(Excerpts, including footnotes, taken from "Improved system for grading ponderosa pine and sugar pine saw logs in trees," by Edward M. Gaines—U.S. Forest Serv., Pacific Southwest Forest and Range Exp. Sta. Tech. Pap 75.)

General Specifications and Definitions

1. These grades are to be applied to 16-foot log lengths as cruised in standing trees; each such log is to be graded solely on its own grade characteristics, without consideration of other logs in the tree.

2. These log grades are designed for application to logs suitable for manufacture into standard lumber grades and sizes as defined by the Western Pine Association.[2] Logs must be live and have a net scale of at least 1/3 or more of gross scale by standard Forest Service scaling procedure. Logs with net scale less than 1/3 of gross scale (culls) are not graded. Dead logs are graded only under special circumstances.

3. **Log grading and log scaling are regarded as separate operations:**

   Log diameter is not considered in grading, even though it may influence the lumber-grade recovery of logs within each log grade.

   Amount of scale deduction in a log is not considered in grading as long as the net scale is 1/3 or more of gross scale.

   Certain types of surface defects, however, are counted as secondary grading defects independent of their consideration in scaling: They are counted in grading whether a deduction is or is not made in scaling.

   Tables of lumber-grade yield (or lumber value) by log grade may include diameter, or percent of scaled defect, or both, as separate variables.

4. **Log face** is a side or portion of the log equal to one-quarter of the circumference and extending the full length of the log.

5. **Surface panel** is a unit of the surface of a log that measures one-quarter the circumference of the log by four feet in length. It is used as a precise and practical way to define the extent to which grading defects are grouped on the total surface of the log, or conversely, the extent to which the log surface is free of grading defects. Surface panels need not be confined to log faces, but may be scattered or staggered up and down and around the log, providing they do not overlap one another. Panels are measured from the edges of their limiting defects: i.e., a grading defect must be entirely within or outside of a panel.

6. **Grading defects** are abnormalities on the surface of the log that influence the quality of the lumber that can be sawn from it. They are generally associated with defects in the lumber that affect its grade adversely. Two classes of defects are recognized: **primary defects** and **secondary defects.**

7. **Primary defects** are log knots; these include limbs, limb stubs (external or overgrown) and holes where limbs have broken out. Ordinarily, no deduction of scaling volume is made for this class of defect, but it is a major indication of lowered lumber grade.

8. **Secondary defects** include:

   a. **Scars** or **seams** due to lightning, fire, or mechanical damage, providing they are old enough that the underlying wood is stained, pitchy, checked, or otherwise degraded.[3]

   b. **Large burls** and **cankers** (burl diameter 1/4 the log circumference or larger).

   c. **Forks** and **crooks** (include all the area of distorted wood surrounding each, but only the distorted wood area.)

   d. **Cracks** due to frost, wind, or other natural causes.

   In many cases, a scaling deduction is made for secondary defects. Sometimes the value of lumber recovered is also reduced, either because scaled-out wood is sawed into low-grade lumber, or because the effect of the defect extends beyond the scaled-out volume. In cases where no scaling deduction is made, grade of lumber may be lowered by blue stain, pitch, etc. Scaling practice has no effect on the grade of the log except when the defect is so serious that the log is culled.

9. **Pseudo-defects** or **false defects** include all distortions or irregularities on the surface of the log that usually have little or no relation to the quality of the lumber beneath. Included are:

   a. **Small burls** (burl diameter less than 1/4 log circumference).

   b. **Bumps**, protuberances that do not indicate underlying knots or scars.

---

[1] These were developed largely from studies of old-growth trees which were 150 years old or older. It is anticipated that additional specifications may be added later for more adequate classification of young-growth logs. (Also See Grade 4 and Footnote 4.)

[2] See the latest edition of "Standard Grading Rules for Lumber" published annually by the Western Pine Association, Portland, Oregon.

[3] This definition should include all scars except those from current-season injuries. Specific project instructions may provide that younger scars will be included in cases where the log will not be utilized until after the underlying wood has had time to become degraded.

c. **Flutes** and **flanges**, if not associated with scars or cracks.

d. **Sapsucker work** ("bird peck").

e. Minor bark distortions of a type that do not indicate underlying knots or scars.

f. Indications of **spiral grain;** severe spiral grain in a log may result in lower quality lumber, but present information is inadequate to identify and evaluate spiral grain as a grading defect.

10. Detailed descriptions of defects and pseudo-defects are found in the supplementary "Guide to Grading Defects for Ponderosa Pine."

11. Primary defects always take precedence over secondary defects. If a surface panel contains both a branch stub and a scar, it is considered as containing a primary defect.

12. Log knots, or other log knot evidence on exposed wood within scars present a special problem of classification. They will be counted as primary defects if a) they are larger than 2 inches in diameter, or b) if the actual wood surface is within 5 inches of where it would be if there were no scar. If the knot or indicator is less than 2 inches in diameter **and** more than 5 inches below the projected "normal" surface, it will be disregarded, and the scar will count as a secondary defect at that point.

Ponderosa Pine Lumber Log Grades

Grade 1

Primary defects are limited to **one**, and this one may not exceed 1/2 inch in diameter (a "pin knot"). It may be located anywhere on the log surface.

Secondary defects are admitted providing they can be confined within not more than three surface panels of the log.

Grade 2

Primary defects are admitted without limit as to number, provided that they can be confined within not more than four surface panels of the log.

Secondary defects are admitted in addition to primary defects, provided that **all grading defects** can be confined within not more than six surface panels of the log.

A log with no primary defects, but with secondary defects affecting four, five, or six surface panels is included in this grade, but a log with primary defects on five surface panels is not admissable, even though it has no secondary defects.

Grade 3

Primary and secondary defects are admitted without limit as to number provided there are at least six surface panels free of **all grading defects**.

Grade 4 [4]

Primary defects are admitted with the following limitations:

1. At least 80 percent must be **bark limbs**. A **bark limb**[5], one to which the bark still adheres, is one that is live or has been dead only a few years and that will result in intergrown or tight, sound knots in lumber.

2. Size of defect is proportional to log diameter at the point of occurrence:

   a. Bark limb: Diameter inside bark at log surface must not exceed 1/6 of log diameter.

   b. All others: Diameter at log surface must not exceed 1/12 of log diameter.

3. Not more than twenty-four primary defects at or near (within 1/2 inch of) maximum size are allowed.

   Secondary defects are admitted, provided they can be confined to three surface panels or less.

Grade 5

All logs not qualifying for grade 1 through 4, but must be at least 1/3 sound by standard Forest Service scaling procedure.

Dead Logs

Logs in dead trees are not usually graded. In special circumstances involving large quantities of dead timber, grading may be desirable. The grades described here may be used in these circumstances. Live and dead logs should always be recorded separately because the quality of lumber deteriorates rather rapidly after the tree dies.

Cull Logs

Logs with net scale less than 1/3 of gross scale are not graded. They are recorded as "cull" when this is necessary to account for the full gross volume of a tree or other unit of timber.

---

[4] Grade 4 was originally conceived to include the best of very knotty logs—those that may be expected to yield a large proportion of "high common" lumber; they are usually upper logs of relatively young trees. The specifications do not adequately define such a grade, but present data are inadequate to develop satisfactory specifications. The present ones will be revised when better data become available.

[5] An exception is the large, long-dead limb in the Southwest and the Black Hills, where bark retention is an indicator of red rot (Polyporus anceps).

Mueller, Lincoln A., and Kovner, J. L.
1967. Lumber production from selected Black Hills ponderosa pine. U. S. Forest Serv. Res. Paper RM-31, 20 pp., illus. Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado. 80521.

Lumber volume and grade recovery information developed from the study of 1,468 logs cut from 498 trees provided a basis for determining the adequacy of the timber-estimating procedure in use by the U. S. Forest Service in the area, and for determining the volume of lumber by grade that can be expected from the range of log diameters and grades available in the Black Hills National Forest. The data also provide for evaluating the performance of the Improved Ponderosa Pine Log Grades, the possibility of weight scaling, as well as information on log scaling and milling practices common to the area.

Mueller, Lincoln A., and Kovner, J. L.
1967. Lumber production from selected Black Hills ponderosa pine. U. S. Forest Serv. Res. Paper RM-31, 20 pp., illus. Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado. 80521.

Lumber volume and grade recovery information developed from the study of 1,468 logs cut from 498 trees provided a basis for determining the adequacy of the timber-estimating procedure in use by the U. S. Forest Service in the area, and for determining the volume of lumber by grade that can be expected from the range of log diameters and grades available in the Black Hills National Forest. The data also provide for evaluating the performance of the Improved Ponderosa Pine Log Grades, the possibility of weight scaling, as well as information on log scaling and milling practices common to the area.

Mueller, Lincoln A., and Kovner, J. L.
1967. Lumber production from selected Black Hills ponderosa pine. U. S. Forest Serv. Res. Paper RM-31, 20 pp., illus. Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado. 80521.

Lumber volume and grade recovery information developed from the study of 1,468 logs cut from 498 trees provided a basis for determining the adequacy of the timber-estimating procedure in use by the U. S. Forest Service in the area, and for determining the volume of lumber by grade that can be expected from the range of log diameters and grades available in the Black Hills National Forest. The data also provide for evaluating the performance of the Improved Ponderosa Pine Log Grades, the possibility of weight scaling, as well as information on log scaling and milling practices common to the area.

Mueller, Lincoln A., and Kovner, J. L.
1967. Lumber production from selected Black Hills ponderosa pine. U. S. Forest Serv. Res. Paper RM-31, 20 pp., illus. Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado. 80521.

Lumber volume and grade recovery information developed from the study of 1,468 logs cut from 498 trees provided a basis for determining the adequacy of the timber-estimating procedure in use by the U. S. Forest Service in the area, and for determining the volume of lumber by grade that can be expected from the range of log diameters and grades available in the Black Hills National Forest. The data also provide for evaluating the performance of the Improved Ponderosa Pine Log Grades, the possibility of weight scaling, as well as information on log scaling and milling practices common to the area.